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Hosono et al.

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(54) **MOBILE COMMUNICATION SYSTEM, BASE STATION, AND MOBILE COMMUNICATION METHOD**

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H04W 24/02 (2009.01)
(Continued)

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CPC ***H04W 72/085*** (2013.01); ***H04W 24/02*** (2013.01); *H04W 36/0083* (2013.01); *H04W 48/18* (2013.01)

(58) **Field of Classification Search**
CPC H04W 16/16; H04W 16/32; H04W 24/02; H04W 24/10; H04W 52/30; H04W 52/32; H04W 52/34; H04W 52/38; H04W 52/40; H04W 52/143; H04W 52/244; H04W 52/245; H04W 56/00
USPC 455/434–444; 370/328–338, 350
See application file for complete search history.

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Primary Examiner — San Htun
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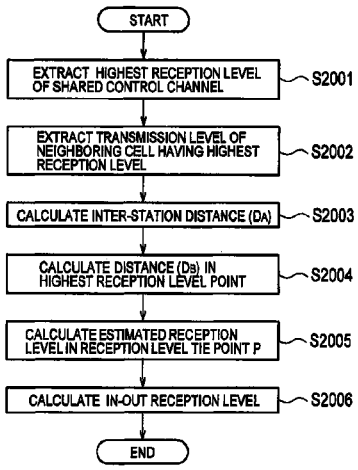
(57) **ABSTRACT**

A radio network controller includes an acquisition unit configured to acquire a radio communication state of a neighboring cell located around a cell formed by a base station which the mobile station camps on among base stations, and a level determination unit configured to determine the in-out reception level based on an acquisition result of the radio communication state by the acquisition unit. The level determination unit calculates an estimated reception level of the radio channel in a reception level tie point P in which the reception level of the radio channel transmitted by a base station **200** and the reception of the radio channel transmitted by a target base station **202** become substantially equal to each other, and determines the in-out reception level based on the calculated estimated reception level α.

6 Claims, 6 Drawing Sheets



(51) **Int. Cl.**
H04W 36/00 (2009.01)
H04W 48/18 (2009.01)

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FIG. 1

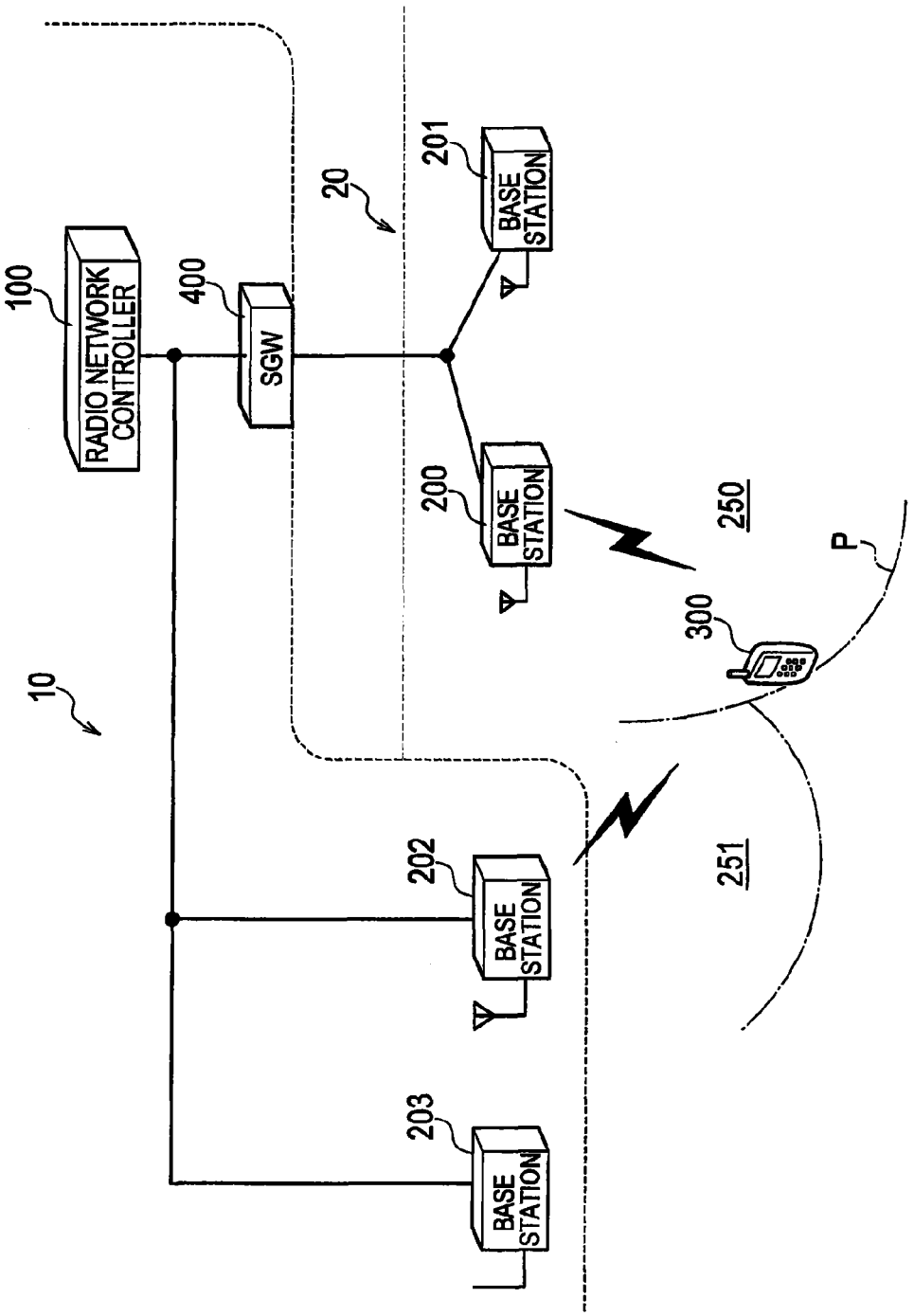

10
100
RADIO NETWORK CONTROLLER
400
SGW
20
201
BASE STATION
200
BASE STATION
202
BASE STATION
203
BASE STATION
250
251
P
300

FIG. 2

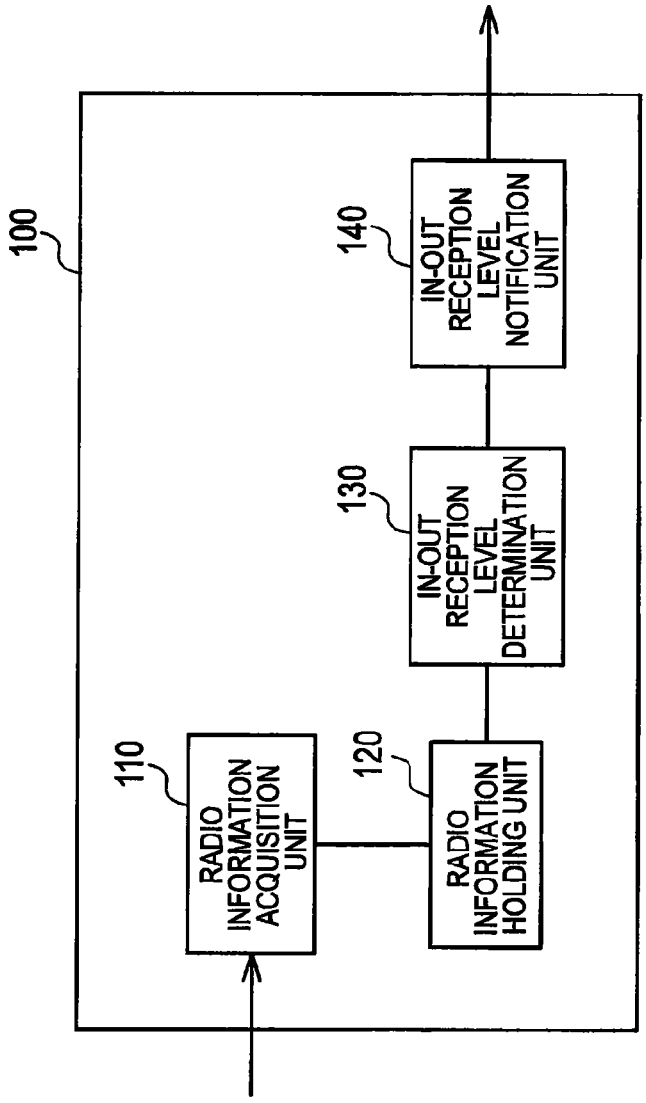
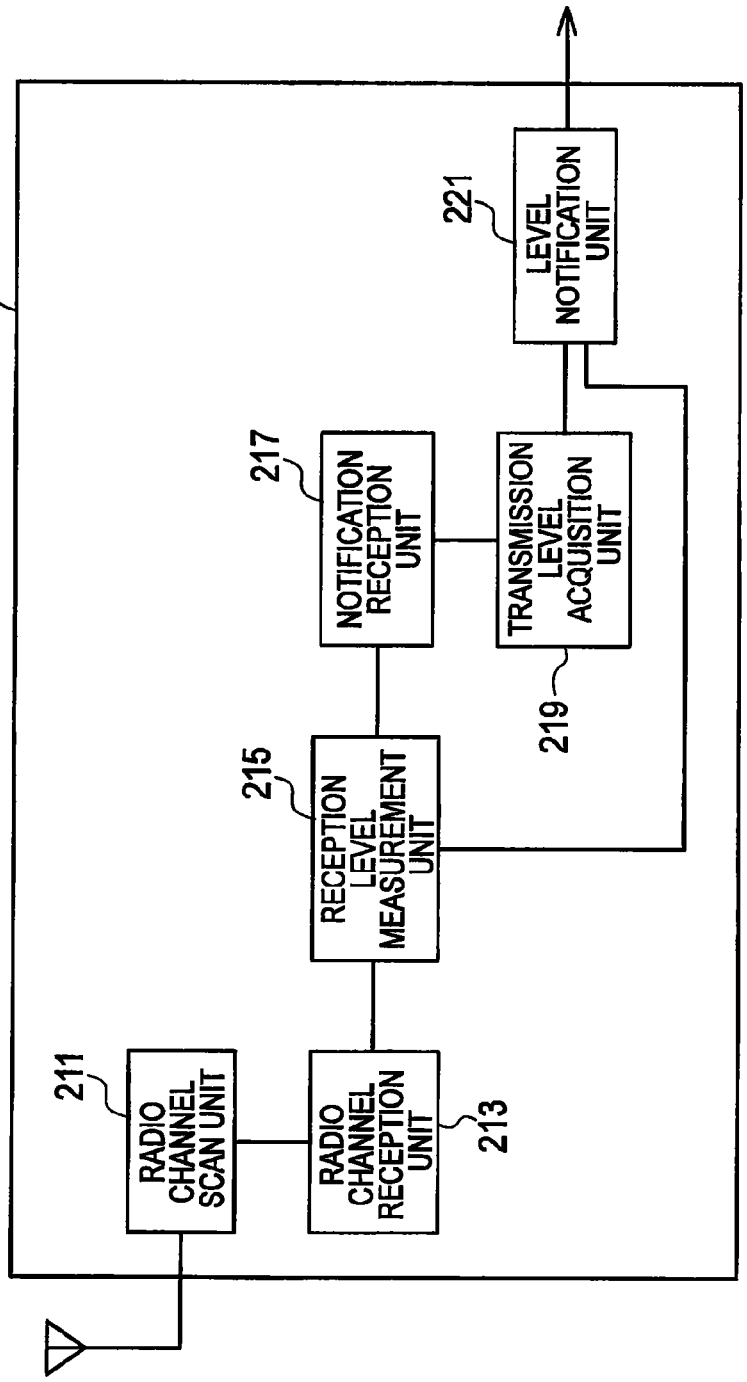

100
110
RADIO INFORMATION ACQUISITION UNIT
120
RADIO INFORMATION HOLDING UNIT
130
IN-OUT RECEPTION LEVEL DETERMINATION UNIT
140
IN-OUT RECEPTION LEVEL NOTIFICATION UNIT

FIG. 3


200
221
LEVEL NOTIFICATION UNIT
217
NOTIFICATION RECEPTION UNIT
TRANSMISSION LEVEL ACQUISITION UNIT
219
215
RECEPTION LEVEL MEASUREMENT UNIT
211
RADIO CHANNEL SCAN UNIT
RADIO CHANNEL RECEPTION UNIT
213

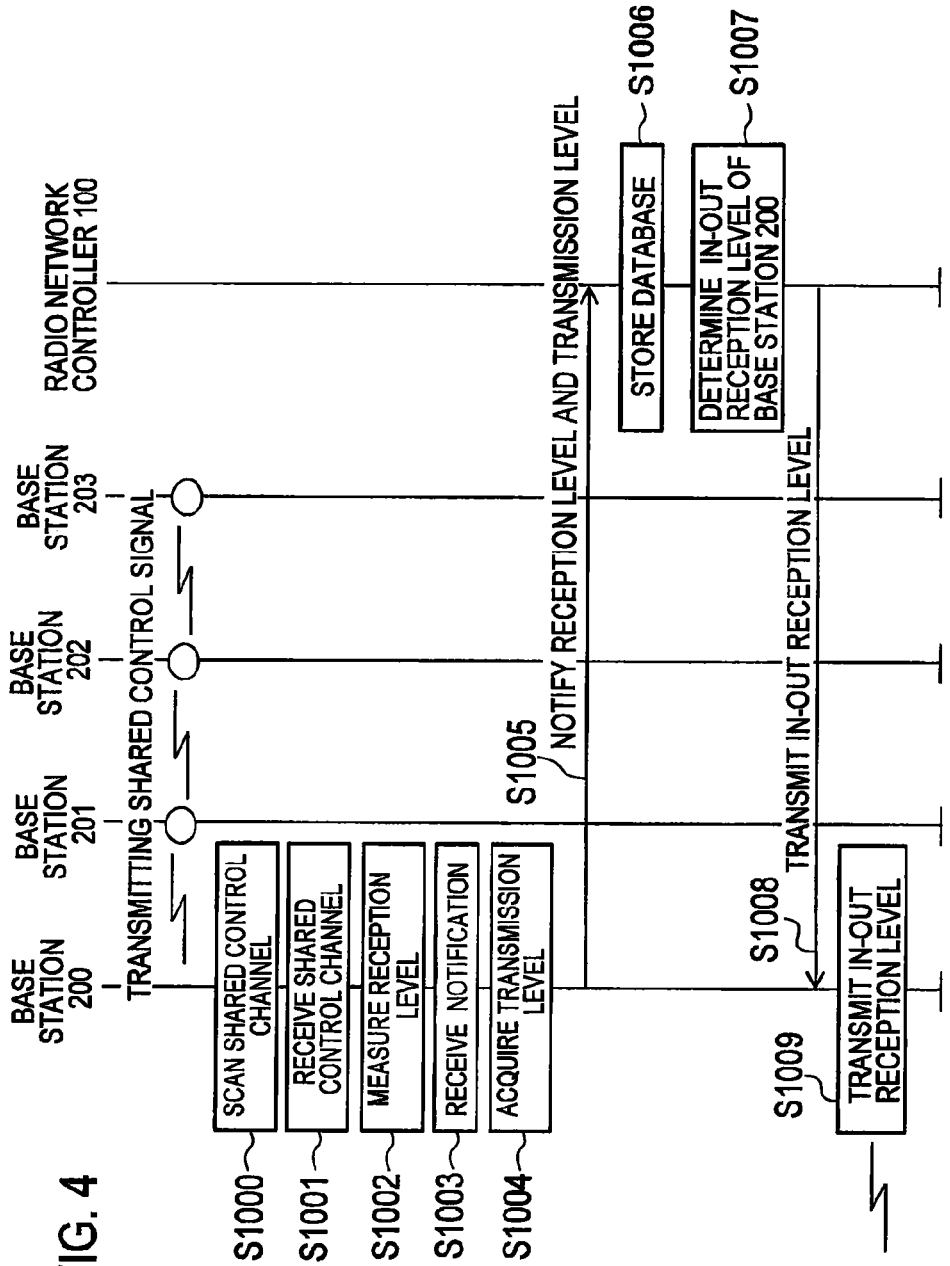

BASE STATION 200
BASE STATION 201
BASE STATION 202
BASE STATION 203
RADIO NETWORK CONTROLLER 100
TRANSMITTING SHARED CONTROL SIGNAL
SCAN SHARED CONTROL CHANNEL
RECEIVE SHARED CONTROL CHANNEL
MEASURE RECEPTION LEVEL
RECEIVE NOTIFICATION
ACQUIRE TRANSMISSION LEVEL
S1000
S1001
S1002
S1003
S1004
S1005
NOTIFY RECEPTION LEVEL AND TRANSMISSION LEVEL
STORE DATABASE
S1006
DETERMINE IN-OUT RECEPTION LEVEL OF BASE STATION 200
S1007
S1008
TRANSMIT IN-OUT RECEPTION LEVEL
S1009
TRANSMIT IN-OUT RECEPTION LEVEL

FIG. 4

FIG. 5

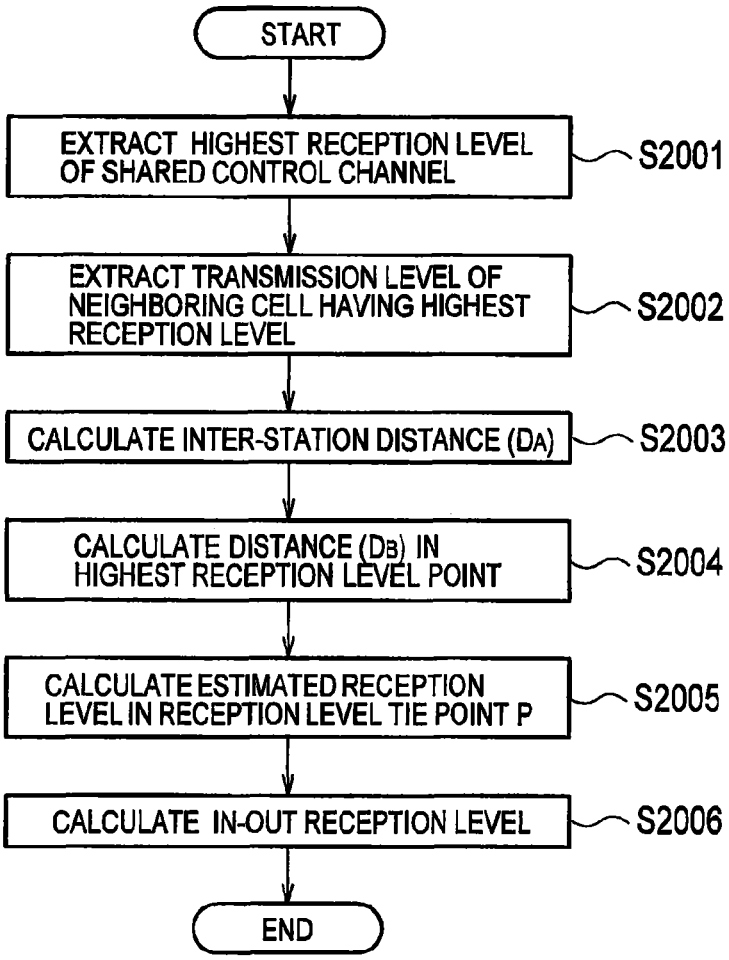
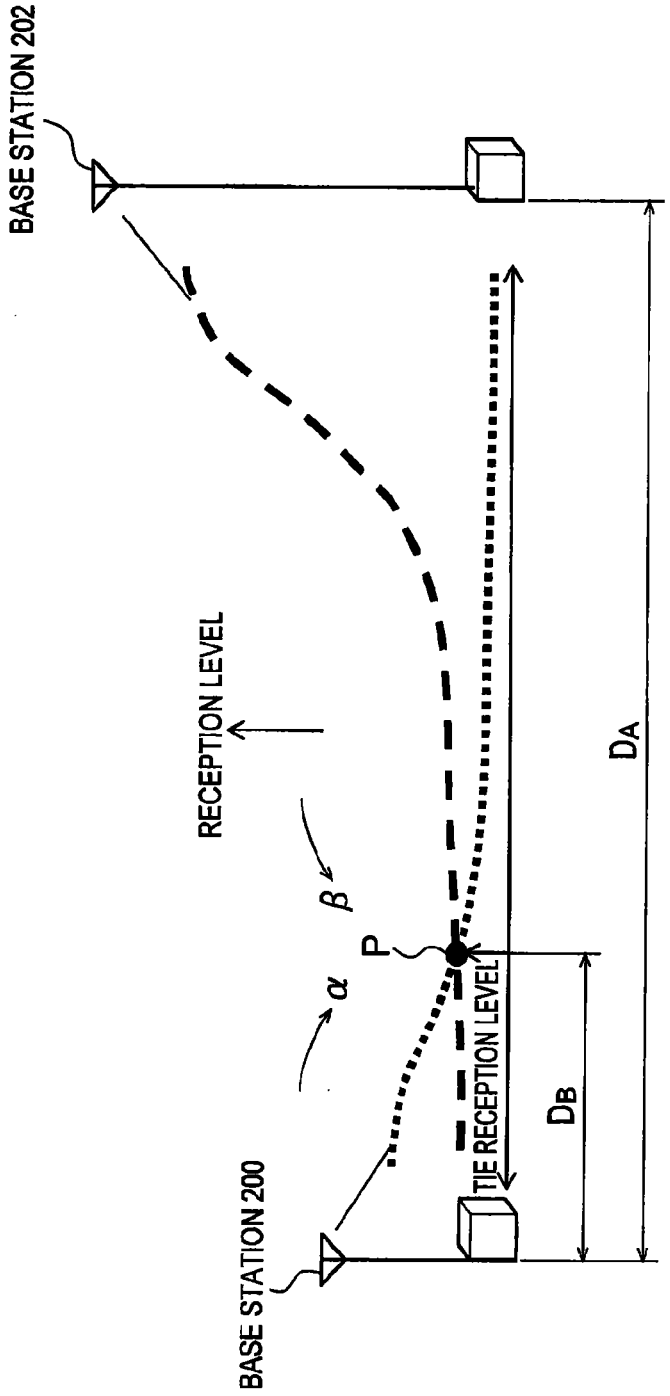


FIG. 6

500

NEIGHBORING BASE STATION	SECTOR	RECEPTION LEVEL OF SHARED CONTROL CHANNEL	TRANSMISSION LEVEL OF SHARED CONTROL CHANNEL
201	1	-110dBm	10dBm
202	1	-90dBm	40dBm
	2	-113dBm	
	3	-115dBm	
203	1	-102dBm	40dBm
	2	-110dBm	

FIG. 7


BASE STATION 202
RECEPTION LEVEL
β
P
α
TIE RECEPTION LEVEL
BASE STATION 200
DA
DB

MOBILE COMMUNICATION SYSTEM, BASE STATION, AND MOBILE COMMUNICATION METHOD

TECHNICAL FIELD

The present invention relates to a mobile communication system, a base station, and a mobile communication method for controlling an in-out reception level for determining whether or not a mobile station is to camp on a cell formed by the base station.

BACKGROUND ART

Mobile communication systems have been required to ensure service qualities in accordance with the contents of communication requests randomly made by mobile stations (users). Thus, when installing a base station, a mobile telecommunications carrier generally estimates the size of a service area and traffic generated in the service area, and uses means such as simulation to design the installation location and configuration of the base station as well as radio parameters such as a transmission level of a downlink common control channel transmitted from the base station.

In addition, in designing such a base station, an in-out reception level is determined which is a reception level indicating whether or not a mobile station is to camp on a cell formed by the base station. For example, in the case of the W-CDMA system, a mobile station camps on the cell when a measured RSCP exceeds Qrxlevmin based on the Qrxlevmin broadcasted from the cell whose measured RSCP is the highest. On the other hand, when the regularly-measured Received Signal Code Power (RSCP) becomes equal to or lower than the Qrxlevmin after completion of the procedure to camp on the cell, the mobile station tries to camp on another cell.

Furthermore, recently, small-sized base stations (Home NodeB) installed by users of mobile stations at home or the like have been increased in addition to base stations for public communications installed by the above-described mobile telecommunications carrier. In the case of a small-sized base station, the users are limited and the size of the cell is small compared with the base station for public communications. Thus, an increase in throughput can be expected (see, NON-PATENT DOCUMENT 1)

PRIOR ART DOCUMENT

Non-Patent Document

NON-PATENT DOCUMENT 1: 3GPP TS 22.220, Service requirements for Home NodeBs (UMTS) and Home eNodeBs (LTE)

SUMMARY OF THE INVENTION

A small base station such as a Home NodeB can be freely installed by a user of a mobile station or the like. Accordingly, the design for a base station by means of such a simulation cannot be employed, and Self Configuration in which a small-sized base station or the like autonomously sets radio parameters is needed.

However, in an apartment and the like, the small base stations are likely to be installed in a crowded manner. Thus, a mobile station of a user cannot always camp on a cell formed by a small base station installed by the user, but may possibly camp on another cell instead. When this happens, the mobile station cannot enjoy advantage of an increase in throughput provided by the small base station.

Thus, an objective of the invention is to provide a mobile communication system, a base station, and a mobile communication method with which a mobile station can securely enjoy advantage of the increase in throughput by a small-sized base station.

A characteristic of the invention relates to a mobile communication system configured to control an in-out reception level for determining whether or not a mobile station (a mobile station **300**) is to camp on a cell formed by a base station (e.g., a base station **200**), the mobile communication system comprising: an acquisition unit (radio information acquisition unit **110**) configured to acquire a radio communication state of a neighboring cell (e.g., cell **251**) located around a cell formed by the base station which the mobile station camps on among base stations, and a level determination unit (in-out reception level determination unit **130**) configured to determine the in-out reception level based on the acquisition result of the radio communication state by the acquisition unit. The acquisition unit acquires a reception level of the base station receiving a radio channel transmitted by the neighboring cell, and a transmission level of the radio channel transmitted by the neighboring cell. Based on the highest reception level among the reception levels of the base station receiving radio channels transmitted by neighboring cells, and the transmission level of the radio channel in a target base station transmitting the radio channel having the highest reception level, the level determination unit calculates an estimated distance between the base station and the target base station. Based on the calculated estimated distance, the level determination unit calculates an estimated reception level of the radio channel in a reception level tie point in which the reception level of the radio channel transmitted by the base station and the reception level of the radio channel transmitted by the target base station become substantially equal to each other, and determines the in-out reception level based on the calculated estimated reception level.

In the above-described characteristic of the invention, the level determination unit may calculate a first estimated reception level based on a propagation loss equation and the transmission level of the radio channel transmitted by the base station, may calculate a second estimated reception level based on the propagation loss equation and the transmission level of the radio channel transmitted by the target base station, may calculate the reception level tie point so that the first estimated reception level and the second estimated reception level become equal to each other, and may determine the calculated first estimated reception level as the in-out reception level.

In the above-described characteristic of the invention, the level determination unit may calculate the in-out reception level by adding a first offset value to the calculated first estimated reception level.

In the above-described characteristic of the invention, the level determination unit may calculate the estimated reception level in the reception level tie point based on a corrected reception level obtained by adding a second offset value to the reception level of the radio channel transmitted by the base station.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an overall schematic configuration diagram of a mobile communication system according to an embodiment of the present invention.

FIG. **2** is a functional block configuration diagram of a radio control unit **100** according to the embodiment of the invention.

FIG. **3** is a functional block configuration diagram of abase station **200** according to the embodiment of the invention.

FIG. **4** is a drawing showing a sequence inside the mobile communication system in relation to the determination of an in-out reception level.

FIG. **5** is a drawing showing a flow in which the radio network controller **100** determines an outside/inside-cell reception level based on data of the reception levels stored in a database **500**.

FIG. **6** is a drawing showing one example of the database **500** storing a reception level and a transmission level.

FIG. **7** is a drawing showing a relationship between reception levels of common control channels (radio channels) which are transmitted by the base station **200** and the base station **202** and a distance.

MODES FOR CARRYING OUT THE INVENTION

Hereinafter, an embodiment of the present invention is described. In the following description of the drawings, same or similar reference numerals are given to denote same or similar portions. Note that the drawings are merely schematically shown and proportions of sizes and the like are different from actual ones.

Thus, specific sizes and the like should be judged by referring to the description below. In addition, there are of course included portions where relationships or percentages of sizes of the drawings are different with respect to one another.

(1) Overall Schematic Configuration of Mobile Communication System

FIG. **1** is an overall schematic configuration diagram of a mobile communication system according to the present embodiment. Specifically, FIG. **1** shows an example of a configuration of a radio access network representative in the mobile communication system.

The mobile communication system shown in FIG. **1** complies with the W-CDMA scheme, and base stations **200** to **203** are communicatively connected to the radio network controller **100**. The radio network controller **100** assigns the base stations **200** to **203** radio parameters required to execute radio communications to the base stations and manages the assignment.

In particular, the mobile communication system according to the embodiment controls an in-out reception level (Qrxlevmin) for determining whether or not the mobile station **300** is to camp on a cell (a cell **250**) formed by a base station (e.g., a base station **200**) installed by a mobile telecommunications carrier or a user receiving a communication service provided by the mobile telecommunications carrier.

The base station **200** and the base station **201** are small-sized base stations (Home eNodeB) managed by a user of the communication service provided by the mobile telecommunications carrier. The base station **200** and the base station **201** are both installed in the Local Area Network (LAN) managed by the user and are connected to the radio network controller **100** provided on the mobile telecommunications carrier network **10** via the access line carrier providing FTTH and ADSL.

A Security Gateway (SGW) **400** is installed in a boundary between the mobile telecommunications carrier network **10** and the access line carrier network **20**. The SGW **400** is a gateway for protecting the mobile telecommunications carrier network **10** against an unauthorized access from other communication networks. The SGW **400** permits only an access to the proper mobile telecommunications carrier network **10** authenticated by a predetermined authentication procedure.

It is assumed in the embodiment that different users respectively have the base station **200** and the base station **201**. For this reason, a mobile station of the user managing one of the base stations is not given of a connection permission to the other of the base stations. On the other hand, a base station **202** and a base station **203** are base stations for public communications and are installed on the mobile telecommunications carrier network **10**. As long as a user has a mobile station of the mobile telecommunications carrier, the user can be connected to the base station **202** and the base station **203** without particular limitations.

(2) Functional Block Configuration of Radio network controller **100**

FIG. **2** is a functional block configuration diagram of the radio network controller **100**. As shown in FIG. **2**, the radio network controller **100** includes a radio information acquisition unit **110**, a radio information holding unit **120**, an in-out reception level determination unit **130**, and an in-out reception level notification unit **140**.

The radio information acquisition unit **110** acquires a radio communication state of a neighboring cell (e.g., a cell **251**) located around a cell (a cell **250**) formed by a base station (e.g., a base station **200**) which the mobile station **300** camps on among the base stations **200** to **203**. Specifically, the radio information acquisition unit **110** acquires a reception level of the base station receiving the radio channel transmitted by a neighboring cell. Specifically, the radio information acquisition unit **110** acquires a reception level of the base station receiving a common control channel used commonly by multiple mobile stations **300**.

Also, the radio information acquisition unit **110** acquires a transmission level of the common control channel transmitted by the neighboring cell. Note that a shared pilot channel (CPICH) or the like, for example, can be used as a channel for control, which is receivable in the neighboring cell.

The mobile information holding unit **120** holds information (the reception level) indicating the radio communication state of the neighboring cell (the base station) acquired by the radio information acquisition unit **110**. Specifically, the radio information holding unit **120** holds the information in a format like the database **500** shown in FIG. **6**.

The in-out reception level determination unit **130** determines an in-out reception level (Qrxlevmin) based on an acquisition result of the radio communication state acquired by the radio information acquisition unit **110**.

Specifically, the in-out reception level determination unit **130** calculates a distance D_A (an estimated distance) between a specific base station (e.g., the base station **200**) and a target neighboring base station (e.g., the base station **202**, hereinafter referred to as a target base station) based on the reception level and transmission level of the common control channel of the neighboring cell acquired by the radio base information acquisition unit **110**. Also, the in-out reception level determination unit **130** calculates a distance D_B between a reception level tie point P in which the reception level of the common control channel transmitted by the specific base station (the base station **200**) and the reception level of the common control channel transmitted by the target base station (the base station **202**) are substantially equal to each other and the base station **200**.

The in-out reception level determination unit **130** calculates an estimated reception level of the common control channel in the reception level tie pint P and determines the in-out reception level based on the calculated estimated reception level. Note that the details of the operation of the in-out reception level determination unit **130** are described later.

The in-out reception level notification unit **140** transmits an in-out reception level determined by the in-out reception level determination unit **130** to the appropriate base station (e.g., the base station **200**).

(3) Functional Block Configuration of Base Station **200**

FIG. **3** is a functional block configuration diagram of the base station **200**. The base station **200** can control the in-out reception level determining whether or not the mobile station **300** is to camp on the cell formed by the base station **200**. As shown in FIG. **3**, the base station **200** includes a radio channel scan unit **211**, a radio channel reception unit **213**, a reception level measurement unit **215**, a notification reception unit **217**, a transmission level acquisition unit **219**, and a level notification unit **221**.

The radio channel scan unit **211** scans the common control channel (a radio channel) of a neighboring cell (e.g., cell **251**) located around the cell **205** formed by the base station **200** which the mobile station **300** camps on among the base stations **200** to **203**. Specifically, the radio channel scan unit **211** performs scanning in a predetermined frequency bandwidth to determine whether or not the common control channel is transmitted.

The radio channel reception unit **213** receives the radio channel of the neighboring cell based on a scan result of the common control channel by the radio channel scan unit **211**. The reception level measurement unit **215** measures a reception level of the common control channel in a neighboring cell received by the radio channel reception unit **220**.

The notification reception unit **217** receives notification broadcasted to the entire cells by the base stations **201** to **203** forming the neighboring cells. The transmission level acquisition unit **219** acquires a transmission level of the common control channel in the cell contained in the notification received by the notification reception unit **217**.

The level notification unit **221** notifies the radio network controller **100** of a reception level of the common control channel measured by the reception level measurement unit **215** and a transmission level of the common control channel acquired by the transmission level acquisition unit **219**.

(4) Operation of Mobile Communication System

Hereinafter, described is an operation of the mobile communication system, specifically, an operation performed by the radio network controller **100** for determining an in-out reception level (Qrxlevmin). FIG. **4** is a drawing showing a sequence inside the mobile communication system in relation to the determination of in-out reception level.

Here, the operation of determining the in-out reception level of the base station **200** is described in a case where a base station **200** is newly installed in a location adjacent to service areas of the base stations **201** to **203** which are already in operation. Note that FIG. **4** shows a sequence in the case where a base station is newly installed, but may similarly show a case where the base station in operation automatically updates an in-out reception level.

As shown in FIG. **4**, a newly-installed base station **200** (Home eNodeB) executes the scanning of the common control channel transmitted by the neighboring cells (the base stations **201** to **203**) and tries to receive the common control channel (Step S**1000**). Here, the base station **200** receives the common control channel transmitted by the base stations **201** to **203** (step S**1001**).

The base station **200** measures a reception level of the common control channel transmitted by the base stations **201** to **203** (step S**1002**). Also, the base station **200** receives the notification transmitted to the entire cells by the base stations **201** to **203** (step S**1003**).

The base station **200** acquires a transmission level of the common control channel contained in the received notification. Specifically, the transmission level of the common control channel transmitted by the base stations **201** to **203** is acquired (step S**1004**). The base station **200** notifies the radio network controller **100** of a measured value of the reception level of the common control channel in the base station **200** transmitted by the base stations **201** to **203** and the reception level of the common control channel transmitted by the base stations **201** to **203**.

The radio network controller **100** stores the reception level and the transmission level which are notified from the base station **200** in the database **500** (step S**1006**). FIG. **6** shows an example of the database **500** storing the reception level and the transmission level. As shown in FIG. **6**, the database **500** includes an identifier for a neighboring base station of the base station **200**, a sector, the reception level of the common control channel, and the transmission level of the common control channel. Note that in the embodiment, the sector is regulated by the combination of the frequency and the service area (radiation direction of radio waves) and the reception level of the common control channel is acquired for each sector. Also, the cell includes multiple sectors using the same frequency, which have different covering service areas. Note that in the embodiment, as a matter of convenient explanation, the description is given as if each sector uses the same frequency.

The radio network controller **100** refers to the database **500** and determines an in-out reception level used in the base station **200** (step S**1007**). Note that a method of determining the in-out reception level is described later.

The radio network controller **100** notifies the base station **200** of the determined in-out reception level (step S**1008**). The base station **200** broadcasts the notified in-out reception level to the mobile station **300** (step S**1009**).

FIG. **5** shows a flow of determining by the radio network controller **100**, specifically, the in-out reception level determination unit **130**, an in-out reception level based on the reception level data stored in the database **500**

The radio network controller **100** extracts a base station having the highest reception level among the reception levels in the base stations **201** to **203** of the common control channel stored in the database **500** (step S**2001**). Specifically, the radio network controller **100** extracts "−90 dBm" of the base station **202** (sector **1**). Furthermore, the radio network controller **100** extracts the transmission level (40 dBm) of the common control channel of the base station (the base station **202**) stored in the database **500** (step S**2002**).

The radio network controller **100** calculates a distance D_A (see FIG. **7**) between the base station **200** and the base station **202** based on the highest reception level (−90 dBm) among the reception levels in the base station **200** of the common control channels transmitted by the neighboring cells (the base stations), and the transmission level (40 dBm) of the

common control channel in the target base station (the base station **202**) transmitting the common control channel of the highest reception level.

Specifically, the radio network controller **100** calculates a distance D_A by using values of the acquired reception level and transmission level and a propagation loss equation (step **S2003**). The propagation loss equation includes a free-space loss equation or an in-house propagation loss equation, and an equation may be properly selected according to the installation state of the base station **200**. Note that each propagation loss equation is as follows.

Free-space loss equation:

$$L[\mathrm{dB}]=32.44+20\times\log(f[\mathrm{MHz}])+20\times\log(d[\mathrm{km}]) \quad \text{[Math 1]}$$

In-house propagation loss equation:

$$L[\mathrm{dB}]=20\times\log(f[\mathrm{MHz}])+N\times\log(d[\mathrm{m}])+L(n)-28 \quad \text{[Math 2]}$$

The parameter N is such that house: 28, office: 30, and commercial facility: 22 in the frequencies of 1.8 to 2.0 GHz. The parameter L(n) is such that house: 4n, office: 15+4*(n−1), commercial facility: 6+3*(n−1) in the frequencies of 1.8 to 2.0 GHz. Note that n is the number of walls through which electric waves pass between the base station and the mobile station.

The radio network controller **10** calculates an estimated reception level of the common control channel in a reception level tie point P in which the reception level of the common control channel transmitted by the base station **200** and the reception level of the common control channel transmitted by the base station **202** (the target base station) become substantially equal to each other. Furthermore, the radio network controller **100** determines the in-out reception level based on the calculated estimated reception level.

FIG. **7** is a drawing showing a relationship between reception levels of common control channels transmitted by the base station **200** and the base station **202** and the distance. In the base station **200**, as moving from the base station itself (base station **200**) to the base station **202**, the reception level of the common control channel of the base station itself decreases while the reception level of the common control channel of the base station **202** increases.

The radio network controller **100** calculates an estimated reception level of the common control channel in the reception level tie point P in which the reception level of the base station **200** (the base station itself, i.e., the base station for which the in-out reception level is determined) and the reception level of the common control channel of the base station **202** tie with each other. The radio network controller **100** perform control such that the value obtained by adding a first offset value to the calculated estimated reception level is used as an in-out reception level of the base station **200**.

Specifically, the radio network controller **100** calculates a distance D_B between the reception level tie point P in which the reception levels of the common control channels of the base station **200** and the base station **202** tie with each other and the base station **200** by substituting the propagation loss obtainable from a difference between the reception level and the transmission level for the above-described propagation loss equation (step **S2004**).

Furthermore, the radio network controller **100** calculates an estimated reception level α (a first estimated reception level) that is a reception level in the reception level tie point P located apart from the base station **200** by the distance D_B based on the transmission level of the common control channel transmitted by the base station **200** and the above-described propagation loss equation. Similarly, the radio network controller **100** calculates an estimated reception level β (a second estimated reception level) that is a reception level in the reception level tie point P located apart from the base station **202** by (the distance D_A—the distance D_B) based on the transmission level of the common control channel transmitted by the base station **202** and the above-described propagation loss equation (step **S2005**).

The radio network controller **100** calculates the reception level tie point P so that the estimated reception level α and the estimated reception level β become equal to each other and determines the calculated estimated reception level α as an in-out reception level (step **S2006**).

Here, in the embodiment, the radio network controller **100** calculates the in-out reception level (Qrxlevmin) by adding the first offset value (e.g., 3 dB) to the calculated estimated reception level α.

(5) Advantageous Effects

The radio network controller **100** according to the embodiment calculates a distance D_A between the base station **200** and the base station **202** based on the highest reception level among the reception levels of the common control channels transmitted by neighboring cells (base stations) and the transmission level of the common control channel in the base station **202** transmitting the common control channel having the highest reception level.

Furthermore, based on the calculated distance D_A, the in-out reception level (Qrxlevmin) is determined based on the estimated reception level of the common control channel in the reception level tie point P in which the reception level of the common control channel transmitted by the base station **200** and the reception level of the common control channel transmitted by the base station **202** become substantially same with each other.

For this reason, the mobile station **300** of the user can be more surely camped on the cell **250** formed by the base station **200** being the small-sized base station installed by the user. In other words, the radio network controller **100** reduces a possibility that the mobile station **300** may camp on another cell and the user of the mobile station **300** can securely enjoy the advantage of the increase in throughput by the base station **200**.

In the embodiment, the reception level tie point P is calculated so that the estimated reception level α from the base station **200** and the estimated reception level β from the base station **202** become equal to each other. For this reason, the estimated reception level in the reception level tie point P can be further correctly calculated. As a result, the mobile station **300** can be further surely camped on the cell **250** formed by the base station **200**.

In the embodiment, the first offset value is added to the calculated estimated reception level α. For this reason, the mobile station **300** can be further surely camped on the cell **250** formed by the base station **200**.

(6) Modification

The radio network controller **100** (the in-out reception level determination unit **130**) may calculate an estimated reception level α in the reception level tie point P based on a corrected reception level in which a second offset value is added to the reception level of the common control channel transmitted by the base station **200**. According to such a modification, the mobile station **300** can be further surely camped on the cell **250** formed by the base station **200**.

(7) Other Embodiments

As described above, the contents of the present invention have been disclosed through the above-described embodiments. However, it should not be understood that the description and the drawings, which constitute one part of this dis-

closure, are to limit the present invention. Various alternative embodiments will be obvious for those who are in the art from this disclosure.

For example, the above-described embodiments of the invention describe the case where a mobile communication system complies with the W-CDMA scheme. However, the base stations **200** to **203** may include functions of the radio network controller **100** in the case of the LTE (Long Term Evolution) that is the next generation system of the W-CDMA. Specifically, the base stations **200** to **203** may include functions of the radio information acquisition unit **110**, radio information holding unit **120**, in-out reception level determination unit **130**, and in-out reception level notification unit **140** of the radio network controller **100**. Note that the base stations **200** to **203** may alternately share a radio communication state acquired by each of the base stations.

Furthermore, part of the functions of the functional blocks of the radio network controller **100** may be executed in the base station.

Also, in the above-described embodiment, the first offset value and the second offset value are used, but such offset values are not necessarily used.

It is natural that the present invention includes various embodiments which are not described herein. Accordingly, the technical scope of the present invention is defined only by particular matters of the invention according to the scope of claims which is appropriate from the above description.

Note that the contents of Japanese Patent Application Publication No. 2010-130535 (filed on Jun. 7, 2010) are hereby incorporated by reference in their entirety.

INDUSTRIAL APPLICABILITY

The invention can provide a mobile communication system, a base station, and a mobile communication method with which a mobile station can securely enjoy advantage of an increase in throughput by a small-sized base station, and therefore is useful in radio communications and the like.

EXPLANATION OF THE REFERENCE NUMERALS

10 . . . mobile telecommunications carrier network
20 . . . access line carrier network
100 . . . radio network controller
110 . . . radio information acquisition unit
120 . . . radio information holding unit
130 . . . in-out reception level determination unit
140 . . . inside/outside-cell threshold notification unit
200 to **203** . . . base station
211 . . . radio channel scan unit
213 . . . radio channel reception unit
215 . . . reception level measurement unit
217 . . . notification reception unit
219 . . . transmission level acquisition unit
221 . . . level notification unit
250, **251** . . . cell
300 . . . mobile station
400 . . . SGW
500 . . . database

The invention claimed is:

1. A mobile communication system which controls an in-out reception level for determining whether or not a mobile station is to camp on a cell formed by a base station, comprising:

circuitry comprising

an acquisition unit configured to acquire a radio communication state of a neighboring cell located around a cell formed by a base station which the mobile station camps on among base stations; and

a level determination unit configured to determine the in-out reception level based on an acquisition result of the radio communication state by the acquisition unit, wherein

the acquisition unit acquires a reception level of the base station receiving a radio channel transmitted by the neighboring cell, and a transmission level of the radio channel transmitted by the neighboring cell, wherein

based on a highest reception level among the reception levels of the base station receiving radio channels transmitted by neighboring cells and a transmission level of the radio channel in a target base station transmitting a radio channel having the highest reception level, the level determination unit calculates an estimated distance between the base station and the target base station,

based on the calculated estimated distance, the level determination unit calculates an estimated reception level of the radio channel in a reception level tie point in which the reception level of the radio channel transmitted by the base station and the reception level of the radio channel transmitted by the target base station become substantially equal to each other, and determines the in-out reception level based on the calculated estimated reception level, and

wherein the level determination unit calculates a first estimated reception level based on a propagation loss equation and the transmission level of the radio channel transmitted by the base station, calculates a second estimated reception level based on the propagation loss equation and the transmission level of the radio channel transmitted by the target base station, calculates the reception level tie point so that the first estimated reception level and the second estimated reception level become equal to each other, and determines the calculated first estimated reception level as the in-out reception level.

2. The mobile communication system according to claim **1**, wherein the level determination unit calculates the in-out reception level by adding a first offset value to the calculated first estimated reception level.

3. The mobile communication system according to claim **1**, wherein the level determination unit calculates the estimated reception level in the reception level tie point based on a corrected reception level obtained by adding a second offset value to the reception level of the radio channel transmitted by the base station.

4. A radio network controller configured to control an in-out reception level for determining whether or not a mobile station is to camp on a cell formed by a base station, comprising:

circuitry comprising

an acquisition unit configured to acquire a radio communication state of a neighboring cell located around a cell formed by a base station which the mobile station camps on among base stations; and

a level determination unit configured to determine the in-out reception level based on an acquisition result of the radio communication state by the acquisition unit, wherein

the acquisition unit acquires a reception level in the base station receiving a radio channel transmitted by the neighboring cell, and a transmission level of the radio channel transmitted by the neighboring cell, wherein

based on a highest reception level among the reception levels of the base station receiving radio channels transmitted by neighboring cells and a transmission level of the radio channel in a target base station transmitting a radio channel having the highest reception level, the level determination unit calculates an estimated distance between the base station and the target base station,

based on the calculated estimated distance, the level determination unit calculates an estimated reception level of the radio channel in a reception level tie point in which the reception level of the radio channel transmitted by the base station and the reception of the radio channel transmitted by the target base station become substantially equal to each other, and determines the in-out reception level based on the calculated estimated reception level, and

wherein the level determination unit calculates a first estimated reception level based on a propagation loss equation and the transmission level of the radio channel transmitted by the base station, calculates a second estimated reception level based on the propagation loss equation and the transmission level of the radio channel transmitted by the target base station, calculates the reception level tie point so that the first estimated reception level and the second estimated reception level become equal to each other, and determines the calculated first estimated reception level as the in-out reception level.

5. A radio communication method for controlling an in-out reception level for determining whether or not a mobile station is to camp on a cell formed by a base station, comprising the steps of:

acquiring a radio communication state of a neighboring cell located around a cell formed by a base station which the mobile station camps on among base stations; and

determining the in-out reception level based on an acquisition result of the acquired radio communication state, wherein

the acquisition step includes acquiring a reception level of the base station receiving a radio channel transmitted by the neighboring cell and acquiring a transmission level of the radio channel transmitted by the neighboring cell,

the determination step includes:

based on a highest reception level among the reception levels of the base station receiving radio channels transmitted by the neighboring cells and a transmission level of the radio channel in a target base station transmitting a radio channel having the highest reception level, calculating an estimated distance between the base station and the target base station,

based on the calculated estimated distance, calculating an estimated reception level of the radio channel in a reception level tie point in which the reception level of the radio channel transmitted by the base station and the reception of the radio channel transmitted by the target base station become substantially equal to each other, and

determining the in-out reception level based on the calculated estimated reception level, and

wherein determining the in-out reception level further includes

calculating a first estimated reception level based on a propagation loss equation and the transmission level of the radio channel transmitted by the base station,

calculating a second estimated reception level based on the propagation loss equation and the transmission level of the radio channel transmitted by the target base station,

calculating the reception level tie point so that the first estimated reception level and the second estimated reception level become equal to each other, and

determining the calculated first estimated reception level as the in-out reception level.

6. A base station configured to control an in-out reception level for determining whether or not a mobile station is to camp on a cell formed by a base station, comprising:

circuitry comprising

a radio channel scan unit configured to scan a radio channel of a neighboring cell located around a cell formed by the base station which the mobile station camps on among base stations; and

a radio channel reception unit configured to receive a radio channel of the neighboring cell;

a reception level measurement unit configured to measure a reception level of the radio channel of the neighboring cell;

a notification reception unit configured to receive notification of the neighboring cell;

a transmission level acquisition unit configured to acquire a transmission level of the radio channel of the neighboring cell;

a level notification unit configured to notify a radio network controller of the reception level measured by the reception level measurement unit and the transmission level acquired by the transmission level acquisition unit; and

wherein the circuitry calculates a first estimated reception level based on a propagation loss equation and the transmission level of the radio channel transmitted by the base station, calculates a second estimated reception level based on the propagation loss equation and the transmission level of a radio channel transmitted by a target base station, calculates a reception level tie point so that the first estimated reception level and the second estimated reception level become equal to each other, and determines the calculated first estimated reception level as the in-out reception level.

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